## IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of

**DE KROON et al** Atty. Ref.: **4662-254**

Serial No. **10/511,344** Group: **1711**

Filed: **May 23, 2005** Examiner: **Haider**

For: **MULTILAYER BLOWN FILM AND PROCESS FO PRODUCTION THEREOF**

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Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

## SUPPLEMENTAL DECLARATION UNDER RULE 132

Sir:

Pursuant to 37 CFR §1.132, the undersigned, **Jan DE KROON**, **Ted BRINK**, and **Atze Jan NIJENHUIS** hereby declare and state that:

1. We are named co-inventors of the invention disclosed and claimed in U.S. Patent Application Serial No. 10/511,344 filed on May 23, 2005, entitled "MULTILAYER BLOWN FILM AND PROCESS FOR PRODUCTION THEREOF" (hereinafter "the '344 application"), and for all times relevant to the facts stated herein have been employed by DSM N.V. at its facility in Geleen, The Netherlands.

2. It was just recently brought to our attention that certain terminology that was used to describe the invention in the '344 application was not entirely accurate and has therefore led to some confusion with respect to the subject matter being claimed therein.

3. Specifically, it was just brought to our attention that the term "blow-molding" was employed in the '344 application to describe the general

melt-processing technique of the present invention. The use of "blow-molding" to describe the invention of the '344 application was an unfortunate choice of terminology since it connotes that a mold (and hence a mold cavity) is employed to form a hollow structure. No such mold is in fact employed by the invention of the '344 application as it is related to a "blown-film process".

4. It has now been fully realized that a "blow-molding" technique is known in the art as one in which a molten tube of resin (called a "parison") is extruded from a circular die into an open mold. The mold is thereafter closed around the parison and air under pressure is fed through the die into the parison which expands the resin tube so as to fill the mold. The expanded tube is then allowed to cool inside the mold so that, upon opening of the mold, a hollow three-dimensional shaped part is obtained.[1]

5. In a "blown film process", a tubular die is employed through which a tube of resin film is extruded in a tower having a collapsing frame at the top. The collapsing frame collapses the extruded film tube so that the tube diameter can be expanded by the introduction of air through the die. The expanded diameter film tube, termed a film "bubble" is cooled in a cooling zone between the extrusion die and the collapsing frame. The collapsed film is typically subjected to slitting and winding operations downstream of the collapsing frame.[2] A description of one conventional "blown film process" is found in US Patent No. 4,101,614, attached hereto as Exhibit 3.

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1 See in this regard, the attached Exhibit 1 from Kirk-Othmer Encyclopedia of Chemical Technology, 1981, vol. 0, pages 11-12 and 31.

2 See in this regard, the attached Exhibit 2 from Kirk-Othmer Encyclopedia of Chemical Technology, 1981, vol. 0, pages 6 and 26.

6. That the intent of the '344 application to describe a "blown film process" is apparent in the Examples thereof. Specifically, at page 6, line 8 under "Comparative Experiment A and Example I", we note that:

> "...a *Bandera blown film line* [was used] equipped with 3 extruders each having an annular die 100 mm in diameter [to form] a film bubble...."

7. Bandera systems are well known to form blown film as evidenced by the following articles:

   http://www.luigibandera.it/pdf/1173716444_news_0307_ENG.pdf

   http://www.film.luigibandera.com/product/indexprod.asp

8. As is evident from the discussion above, therefore, a mold with its attendant mold cavity is not employed in the practice of the invention of the '344 application. Instead, a blown-film process is employed wherein the resulting product is a multilayer film, not a hollow three-dimensional shaped part.

9. We now fully realize that the term "blow moulding" as used in the '344 application occurred by inadvertent error which was the result of our not fully comprehending art recognized meaning of such term. Instead, it was our intent to describe an invention wherein a film is produced by blowing up an extruded film tube, cooling the extruded film tube and then collapsing the same. That is, it is now realized that we should have more accurately used the term "blown film" to describe the process of the '344 application.

10. The inadvertent use of the inaccurate terminology as discussed above was most recently employed in the "Declaration Under Rule 132" which was executed by the undersigned, Ted Brink, and was filed in the '344 application with the "Response After Final Rejection" on March 21, 2008. At that time, the term "blow-molding" was in fact intended to refer to "blown film processing" for the reasons noted above. In order to ensure clarity in the record, the facts stated in such prior Declaration are restated below with the exception being that accurate terminology has been employed:

**Comparative Experiment A and Example I**

The bubble stability in Example I where the polyamide (PA) layer is the branched polyamide-6 (PA6) has a better bubble stability than Comparative Experiment A where the inner layer is the standard linear (non-branched) PA6. The bubble stability was determined visually by observing the degree of vibrations of the film. My observations were that the multilayer film of Example I clearly exhibited significantly higher bubble stability with a lower degree of vibration during blown film processing as compared to Comparative Experiment A.

**Comparative Experiment B**

In this comparative experiment, the process of Comparative Experiment A was repeated, except that 30 wt.% LDPE in the outer layer of PE mixture was replaced with LLDPE so that the PE layer was formed of a mixture of 90 wt.% LLDPE and 10wt.% Yparex 0H040. It was clear from visual inspection that

such a change had a strong influence on the bubble stability. Specifically, replacing 30wt% LDPE with LLDPE so that the PE layer had 90 wt% LLDPE (instead of 60wt% LLDPE) made it impossible to control the blown film process in such a way as to obtain a bubble with sufficient stability. It was observed in this regard that strong bubble vibrations occurred when the multilayer film of Comparative Experiment B was formed by blown film processing resulting in frequent bubble collapse.

**Example II and III**

This experimental evidence was obtained under the same conditions as Comparative Experiment B, except the linear PA6 was replaced with the branched PA6 employed in Example I. When formed by blown film processing, the bubble remained stable. The good stability of the bubble was also confirmed by the fact that it was possible to increase the blow-up ratio from 2.1 to 2.5.

11. We declare further that all statements made herein of our own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

Respectfully Submitted,

23/6-2009
Date Signed

Jan DE KROON

23/6/2009
Date Signed

Ted BRINK

Date Signed

Atze Jan NIJENHUIS

(41,59,60). It is most frequently used with polyethylene, high impact polystyrene, polypropylene, and several engineering resins. Some modifications to the resin, machine, and mold are required, and a blowing agent must be added to the resin. A chemical blowing agent, which releases gas when heated, is commonly used. The choice of blowing agents depends on the processing temperature required. The most common blowing agent is azodicarbonamide (1,1′-azobisformamide) used at 200–260°C. Upon decomposition, it releases nitrogen, carbon monoxide, and carbon dioxide (qv). Approximately 0.5 wt % of a blowing agent is normally added to the resin pellet as a surface coating or as a pelletized concentrate. Instead of a chemical blowing agent, nitrogen may be mixed with the melt while it is under pressure in an extruder and the mixture maintained under pressure until it is injected into the mold.

The injection molding machine must be equipped with a shutoff nozzle that maintains the melt under pressure while the mold is opened. The screw is retracted only part of the way needed for a full shot, and a short shot is injected into the mold. Without a blowing agent, only a section of a part, ie, a short shot, would be made; the empty space allows the blowing agent to expand the melt, forming the foam structure. Structural foam molding is limited to parts with wall thicknesses of at least 6 mm; below that thickness, reduction in part weight is usually insignificant. Parts, typically, have a dense skin and a foamed interior with various pore sizes. Compared to injection molded surfaces, the surfaces of structural-foam moldings are poor, and are characterized by a rough, swirly finish. Maximum pressure in the mold during foaming is much lower than in injection molding; also, no packing pressure needs to be maintained since the gas keeps the melt front moving. Surface appearance is improved by special techniques.

Because of low injection pressure, some cost savings are possible in mold and press construction. Molding cycles are somewhat longer than for injection molding. The part must be cooled in the mold long enough to be able to resist swelling from internal gas pressure. In structural foam parts there is almost a total absence of sink marks, even in the case of unequal section thickness. Structural foam has replaced wood, concrete, solid plastics, and metals in a variety of applications.

*Blow Molding.* Blow molding is the most common process for making hollow thermoplastic components (61–63). In extrusion blow molding a molten tube of resin called a parison is extruded from a die into an open mold (Fig. 15**a**). In Figure 15**b** the mold is closed around the parison, and the bottom of the parison is pinched together by the mold. Air under pressure is fed through the die into the parison, which expands to fill the mold. The part is cooled as it is held under internal air pressure. Figure 15**c** shows the open mold with the part falling free.

As the parison is extruded, the melt is free to swell and sag. The process requires a viscous resin with consistent swell and sag melt properties. For a large container the machine is usually equipped with a cylinder and a piston called an accumulator. The accumulator is filled with melt from the extruder and emptied at a much faster rate to form a large parison; this minimizes the sag of the molten tube.

With a simple parison, the large-diameter sections of the bottle have a thin wall and the small-diameter sections have a thick wall. Certain modifications of

the die can control the thickness of the parison wall along its length, which results in a bottle with improved wall thickness distribution and better strength. The most common blow molding resin is HDPE used to produce containers ranging in size from 30 $cm^3$ to 200 L.

In injection blow molding, a parison is injection molded onto a core pin; the parison is then rapidly transferred via the core pin to a blow mold, where it is blown by air into an article. This process is applied to small and intricate bottles.

Soft-drink bottles made from PET are usually made by stretch-blow molding in a two-step process. First, a test-tube-shaped preform is molded, which is then reheated to just above its glass-transition temperature, stretched, and blown. Stretching the PET produces biaxial orientation, which improves transparency, strength, and toughness of the bottle. A one-step process is used for many custom containers that are injection stretch-blow molded.

Development–trends in blow molding focus on the optimization of the viscoelastic properties and improvement in thermal stability of polymers other than HDPE to develop new extrusion–*injection* blow molding grades; fabrication of small containers by multilayer blow molding for improved barrier properties to water, oxygen or hydrocarbons; prediction through software packages of wall thickness for parisons and final parts to minimize materials usage.

**4.2. Rotational Molding.** Hollow articles and large, complex shapes are made by rotational molding, usually from polyethylene powder of relatively low viscosity (64–66). The resin is in the form of a fine powder. A measured quantity is placed inside an aluminum mold and the mold is heated in an oven and rotated at low speed. The resin sinters and fuses, coating the inside of the mold. The mold is then cooled by water spray and the part solidifies, duplicating the inside of the mold.

A rotomolding machine has three long arms extending from a central driving mechanism; each arm rotates several molds in two planes. The arms are moved from one process station to the next, ie, from unloading and loading to heating and cooling. Tooling costs are low. The molds are usually made of cast aluminum, but sheet metal is also used. The melt is forced without pressure against the mold surface during heating or cooling, resulting in uniform wall thickness, zero orientation, and high physical properties. Cycle times are long because of the heating and cooling required; they depend on wall thickness and can be as high as 15 min for a 4-mm wall thickness. Common rotomolded products include large tanks and boxes, drums, furniture, and toys. The PVC plastisol, a mixture of fine PVC particles and a plasticizer, may also be processed by rotomolding. Plastisols are liquid at room temperature and are converted to soft solids when heated to ca 180C. Playballs and toys are made from plastisols.

Among recent trends and developments in rotomolding are the use of microprocessors and temperature sensors for quality assurance, the refinement of methods to produce multiwalled solid or foamed structures all coupled with the continuing availability of new resin grades with suitable viscosities and high thermo oxidative stability over the prolonged periods of time in the oven.

**4.3. Expandable Polystyrene Molding.** Molding expandable polystyrene gives foamed products such as insulation board shapes for packaging and disposable food and cup containers. Such processes are also called bead or steam molding (67,68). Expandable polystyrene moldings are manufactured

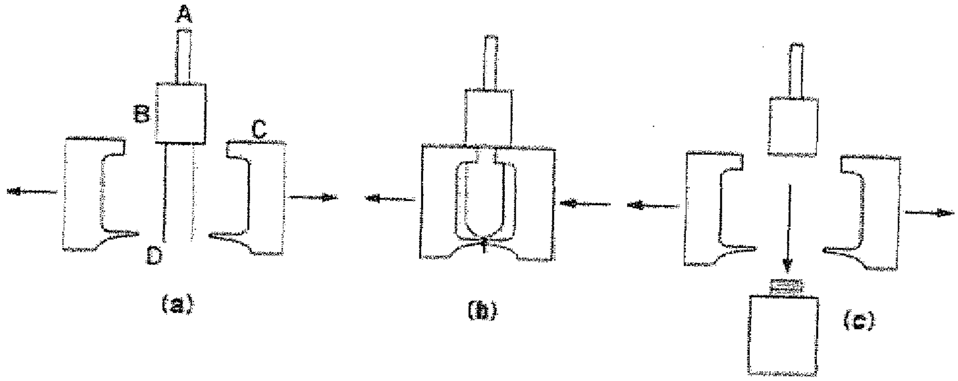



**Fig. 15.** Three stages of blow molding (**a–c**): A, air line; B, die; C, mold; and D, parison. See text.

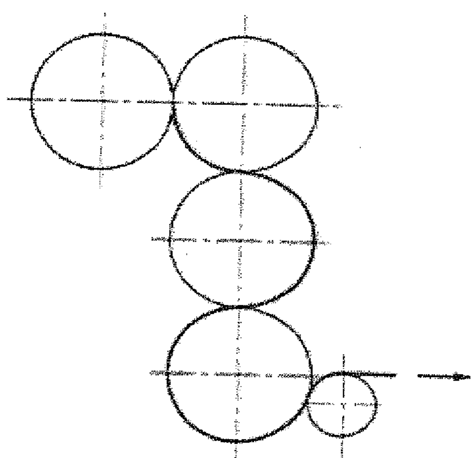


**Fig. 16.** A four-roll, inverted "L" calender.

**3.5. Blown Film.** The blown film process (Fig. 6) uses a tubular die from which the extrudate expands in diameter while traveling upward to a film tower. The top of the tower has a collapsing frame followed by guide and pull rolls to transport the collapsed film to subsequent slitting and windup rolls. The tubular bubble from the die is inflated to the desired diameter by air passing through the center of the die. Although primary cooling to solidify the melt is supplied by an external air ring, chilled air may also be used internally. Polyethylene is the primary plastic used in most films, especially for packaging and trash bags. Coaxial dies can be used for manufacture of coextruded multilayer films.

The tube is characterized by its blow-up ratio, ie, a larger diameter than the die opening, which is expressed as the ratio of bubble diameter to the die diameter. Typical blow-up ratios range from 2:1 to 4:1. The final film thickness is much thinner than the die gap. Die gaps are slits of ~0.65 mm. Typical film thicknesses are 0.007–0.125 mm. The process requires a high melt viscosity resin so that the melt can be pulled from the die in an upward direction. Since only air is used for cooling, removal of heat tends to be slow and rate limiting. Chilled air can also be used internally to improve the efficiency of the air cooling process. The film may be treated for subsequent printing, and it can be slit into various widths and wound onto separate cores.

**3.6. Cast Film.** The cast film process provides a film with gloss and sparkle and can be used with various resins. Figure 7 is an illustration of the essential features of the extrusion equipment. The die opening is a long straight slit with an adjustable gap ~0.4 mm wide. The die is positioned carefully with respect to the casting roll. The casting or chill roll is highly polished and plated and imparts a smooth and virtually flawless surface to the film. The roll is cooled by rapid circulation of water. Temperature control is critical. A die somewhat longer than the width of the film is needed, because the molten web becomes narrow as it is drawn from the die; this is called neck-in. Edges of the film thicken and are mechanically removed before the film is wound on a roll. The edge trim can be reprocessed.

One of the requirements of this process is that the melt maintain good contact with the chill roll, ie, air must not pass between the film and the roll. Otherwise, air insulates the plastic and causes it to cool at a rate different from the rest of the plastic and this spoils the appearance of an otherwise satisfactory product. The melt should not emit volatiles, which condense on the chill roll, reduce heat transfer, and mar the film's appearance. The cast film process allows the use of a higher melt temperature than is characteristic of the blown film process. The higher temperature imparts better optical properties.

Film stretching is a process to impart biaxial orientation in the film by stretching it in two directions simultaneously, the transverse and machine directions, respectively. The process is carried out in a device that grips the edges of the film and extends them to larger widths as the film moves from the inlet to the exit roller. The objective is to increase the modulus and strength of the film uniformly along the entire film plane. Both PP and PET have been used successfully in this process (37).

**3.7. Sheet.** The process used to make an extruded plastic sheet is illustrated in Figure 8. Sheeting thicknesses are 0.25–5 mm and widths are as great as 3 m. Heavier gauge sheets are usually cut to a specified length and

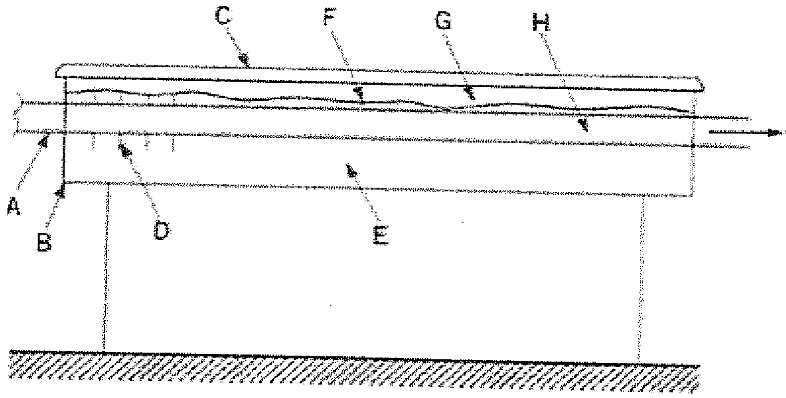



**Fig. 5.** Vacuum calibrator for pipe and tubing extrusion: A, molten tube from die; B, tank; C, hinged cover with gasket; D, sizing rings; E, circulated and temperature controlled water; F, water level; G, vacuum; and H, inside of pipe open to atmospheric pressure (20).

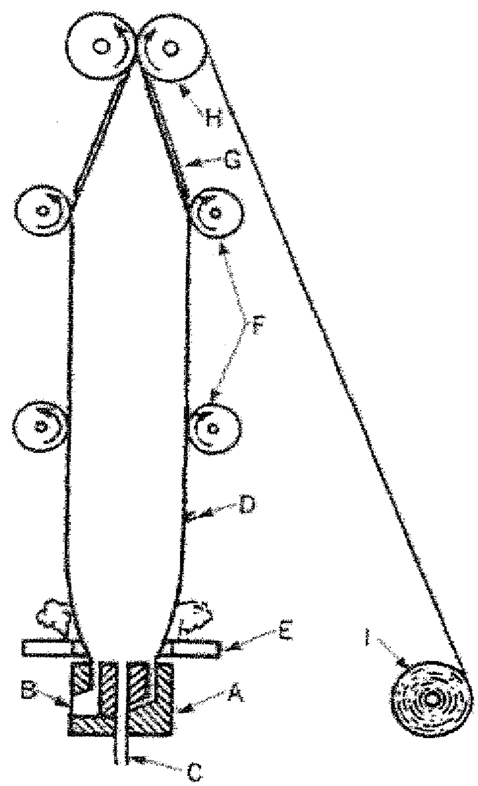



**Fig. 6.** Extrusion of blown film: A, blown-film die; B, die inlet; C, air hole and valve; D, plastic tube (bubble); E, air ring for cooling; F, guide rolls; G, collapsing frame; H, pull rolls; and I, windup roll (20).

United States Patent [19]
Havens

[11] 4,101,614
[45] Jul. 18, 1978

# [54] BLOWN FILM PROCESS

[75] Inventor: Carl B. Havens, Fresno, Calif.

[73] Assignee: The Dow Chemical Company, Midland, Mich.

[21] Appl. No.: 710,984

[22] Filed: Aug. 2, 1976

**Related U.S. Application Data**

[63] Continuation of Ser. No. 554,951, Mar. 3, 1975, abandoned, which is a continuation of Ser. No. 376,834, Jul. 5, 1973, abandoned.

[51] Int. Cl.[2] ............ B29F 3/08

[52] U.S. Cl. ............ 264/40.6; 264/95; 264/237; 425/143; 425/326.1

[58] Field of Search ............ 264/89, 95, 210 R, 237, 264/40.1, 348, 40.6; 425/143, 170, 72, 326 R, 326.1

[56] **References Cited**

U.S. PATENT DOCUMENTS

| | | | |
|---|---|---|---|
| 3,092,874 | 6/1963 | Faliwell | 264/40.1 |
| 3,125,616 | 3/1964 | Cook et al. | 264/40.1 |

OTHER PUBLICATIONS

Film Cooling & Frost Line–Polyethylene Film Extrusion–*An Operating Manual* – U.S.I.–1960–Nat. Dist. & Chem. Corp. pp. 27–30.

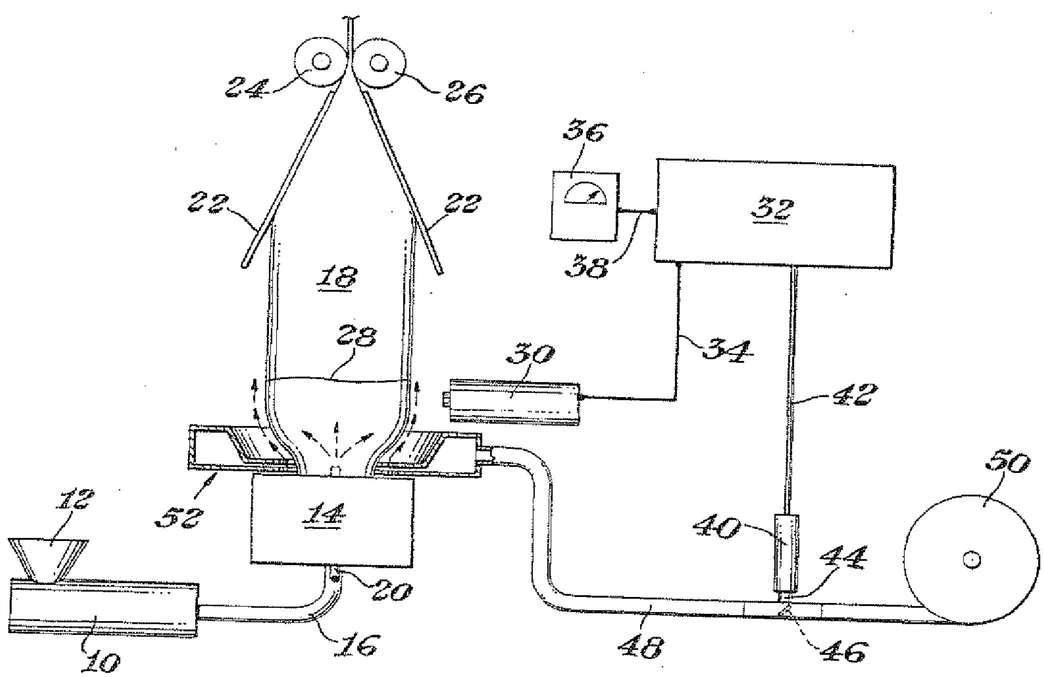
"Effect of Extrusion Variables on the Fundamental Properties of Tubular Film"–*Plastics,* 4–1961 –vol. 26 –Clegg – pp. 114–116.

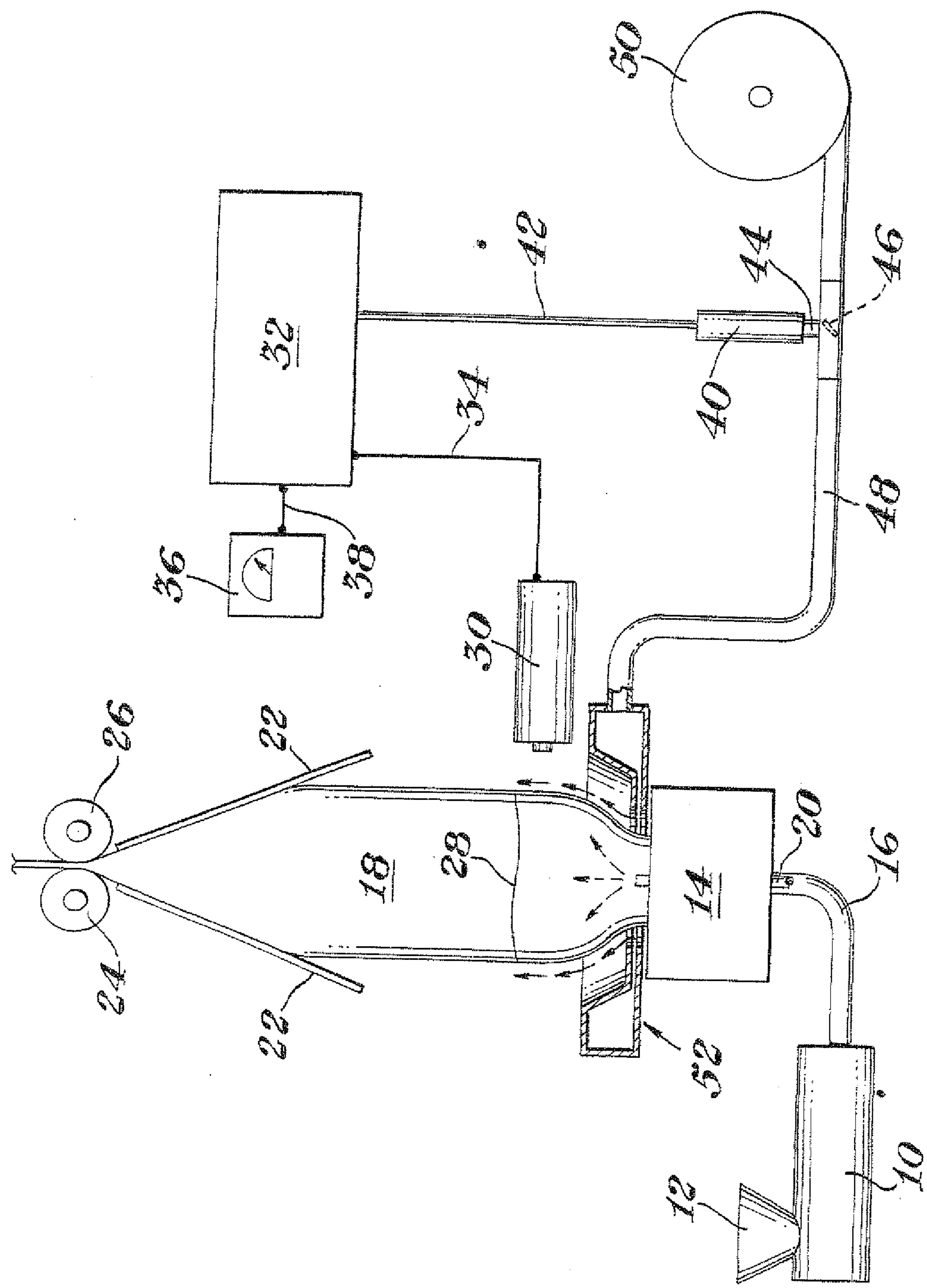
*Primary Examiner*—Jeffery R. Thurlow
*Attorney, Agent, or Firm*—Burke M. Halldorson; Tai-Sam Choo

[57] **ABSTRACT**

A blown film process wherein: the temperature of the film is continually monitored in a select control or target area that is remote from the film frost line; a control of "target temperature" is determined based empirically or otherwise on a given set of companion operating conditions; and a variable film cooling source or supply is regulated to establish the control temperature as an essentially constant or non-variable operating condition. The process is characterized by an essentially stable frost line position and to the extent movement of the frost line can be optically or otherwise observed or sensed, and an appropriate signal derived therefrom, the process can be alternately practiced based on monitoring the position of the frost line, defining a control or "target" frost line position, and regulating a film cooling source responsive to deviances or movement from the control position.

**2 Claims, 1 Drawing Figure**

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# BLOWN FILM PROCESS

This application is a continuation of prior application Ser. No. 554,951, filed Mar. 3, 1975, now abandoned, and which is a continuation of application Ser. No. 376,834, filed July 5, 1973, now abandoned.

## FIELD OF THE INVENTION

The blown film process as expressed or intended herein, is meant to refer broadly to the manufacture of plastic film (including sheet materials) through extruding a continuous molten tube of heat plastified resin, stretching or drawing the tube about a trapped air or gas bubble, and simultaneously cooling the plastic such as by external or internal cooling means. The invention particularly relates to such a process wherein a control area is defined, a control temperature determined for such area, and maintained through variable cooling steps, whereby improved film quality, and/or increased maximum production rates or ceilings are achieved. Alternately the invention concerns defining a controlled frost line position, monitoring such position, and providing a variable cooling means to correct deviations therefrom, for essentially like purposes and improved results.

## BACKGROUND OF THE INVENTION

The ultimate properties and quality of blown film can be adversely affected particularly by cyclic variations in operating conditions, and by less than perfect regularity and consistency as regards the extruded resin. For example the temperature of the extrusion apparatus tends to have inherent cyclic character. Also cyclic conditions occur in conventional film cooling systems, whether based on a refrigerated source or if taken from ambient air. Additionally, film extruders frequently require a filtering system that will gradually clog with impurities, thus inducing a variable effect, particularly a change in melt index, in the resin passed through the filter. The resin itself may not be entirely consistant in quality, such as its melt index value and melt temperature.

Operating inconsistencies such of the above type can produce poor film in the sense of poor film flatness (i.e. appearance of wrinkles in the film) and poor uniformity of the gauge profile of the film. The gauge profile can be somewhat controlled by thickness measuring devices and systems, which give the operator some indication and warning when profile control is deteriorating, so that the appropriate control corrections can be made. However, when conditions go awry causing wrinkles to appear, there have not been good devices to predict this approaching condition, and to give the operator adequate warning to make appropriate corrections.

Thus even with close attention by a skilled operator, it has been difficult to control film quality above certain ceiling production rates. Even when operating within a production range considered manageable by a skilled operator, the film quality can be less than desired and less than specification tolerances, due to imprecise and inadequate control over cyclic and/or fluctuating operating conditions.

Accordingly, it would be advantageous to the art if there were available a blown film process which achieved finer and more precise control over film quality and/or properties.

It would be particularly advantageous if such a process provided a sufficient automatic counter-balancing effect to fluctuating and/or cyclic operating conditions to permit a significant increase in the possible rate of extrusion, while retaining an acceptable level of quality in the film produced, and/or which would consistently produce better quality film.



## SUMMARY OF THE INVENTION

Briefly these and other objectives of the invention are achieved in blown film process using as a base control, the monitoring of a select control area of the film, or alternately, the monitoring of the position of the film frost line. A control temperature or control frost line position is determined which reflects the condition whereby good and preferably optimum quality film is produced, as per any given set of companion operating conditions. A variable cooling source is regulated responsive to signals received from the monitoring device, to stabilize and maintain the control temperature or control position, as applies, as an essentially constant operating condition. This system control provides precise, automatic control over film properties. It is particularly advantageous in providing prompt corrective response to the approaching condition of loss of film flatness, for which there has been inadequate warning or predicting systems in the past.

## DETAILED DESCRIPTION OF THE INVENTION

The accompanying drawing illustrates a blown film process wherein there is represented and practiced a preferred embodiment of the inventive teaching and principles hereof.

Referring particularly to the drawing, a film forming resin is introduced into a heated extruder **10** through a hopper entry means **12**, from whence it is eventually expelled in a heat plastified condition to a die head **14** by way of a connecting pipe or conduit **16**. The resin emerges from the die in the form of a continuous tube or tubular envelope **18**. The tube is stretched or drawn about a trapped bubble that is maintained and replenished by a regulated pressure line **20** that introduces generally controlled amounts of air or gas internally to the tube. A collapsing rack **22**, and cooperating nip rolls **24** and **26**, eventually collapse and flatten the tube at an area remote from the die head. This process will also typically include drive rolls comprising or located beyond nip rolls **24** and **26**, to provide a pulling force to advance the tubing from the die. The speed of the drive rolls is controlled to stretch or draw the tubing longitudinally, and this speed factor, together with other controlling factors, will determine the circumferential size of this tube (i.e., whether it is distended, drawn-down, or maintained essentially the same as extruded size). The area of stretching occurs essentially between the die head and the film frost line shown at **28**. Above the frost line, the film has advanced to a solidified or semi-solidified condition.

The invention particularly concerns a temperature sensing device **30** that is focused to read and continually monitor the temperature of the film in a control or target area that is underneath frost line **28**, and above die head **14**. The area of the film directly adjacent the frost line is not a good predictive or control area. This is presumably because of film crystallization effects near the frost line which tend to cause a stable temperature reading, or a reading which is not adequately predictive of changing conditions for which the control process hereof is designed to correct automatically. A good

predictive control area, however, will exist at an area remote from and spaced sufficiently downwardly from the frost line so as to be less influenced (or non-influenced) by crystallization effects occurring at and in the near vicinity of the frost line.

The signal produced by the temperature sensing device, or the output of this device, is fed to a controller or controlling means **32** through an electrical lead or connection **34**, and also to a temperature reading or recording instrument **36**, through an electrical lead or connection **38**. The temperature reading instrument converts the signal to a dial reading, thus permitting the temperature in the control area to be determined numerically at any given time in the operation.

The output of the controller, is suited to operate an air motor or valve positioner device **40**, through a pneumatic line connection **42** therewith. The valve positioner is connected by a suitable linkage assembly **44** to operate and position a butterfly type valve **46**. The butterfly valve is inset in a cooling air or gas line **48** which delivers air from a blower or compressor unit **50**, to a cooling ring **52** that is disposed about the lower extreme or tube **18**, just above die head **14**.

The system depends on the selection or determination of a control or target temperature for the control area. This is most expediently determined empirically, by arriving at a given set of operating conditions that produce optimum quality film. Upon determining a set of such conditions, the temperature in the control area is read and established as the control temperature. The dial reading while not essential in running the controls, permits the operator to observe and record, if desired, the temperature in the control area. The controller is set to continually compare the signal received from the sensing device, with the control temperature, or equivalently a pre-determined control signal. If the signal would indicate the temperature in the monitored area is rising, the controller notes the difference, and directs the valve positioner **40** to proportionately move the butterfly valve to permit increased air flow to cooling ring **52**, to bring the temperature in the control area downwardly to the control temperature. Alternately a temperature drop is responded to by regulating the butterfly valve to decrease the flow or output of cooling ring **52**. Necessarily the null position, that is, the position the valve assumes when reading a stable temperature condition, is at a point between the extreme open and extreme closed positions of the butterfly valve.

The invention may also be practiced utilizing the height or position of the frost line as the control indicator. The monitoring device would be modified to optically or otherwise read the frost line height and produce signals indicating deviances therefrom. The control frost line position can be determined as before, that is, by operating empirically to define a given set of conditions under which quality film is produced, and defining the control position as that at which the frost line resides under such conditions. The signal provided by the monitoring device would be fed to the controller, and compared with a control signal, and corrective action taken, as required, to regulate air line **48**, to thereby maintain or stabilize the control position.

The control process taught herein is applicable broadly to the production of plastic film, from film forming synthetic resin materials, based on the blown film process(s). Representative examples of films typically produced by this process are: polyethylene and known copolymers of ethylene and various other copolymerizing agents such as propylene, acrylic acid, ethyl acrylate, etc.; polypropylene and known copolymers thereof, film forming polyesters, polystyrene and known copolymers thereof, vinyls such as polyvinyl chloride; saran; film forming polyamides and the like.



The monitoring devices applicable for use in the invention would be heat sensing devices such as a suitable optical pyrometer or radiation thermometer, and thermal-couples or thermistors such as of the feather sensor type, applicable for delicate web materials. When the control is based on a controlled frost line position, a haze meter can be employed to read the position of the frost line, and to produce or generate a signal upon which to base or regulate the film cooling source.

The controller is preferably of the type adapted to compare the input signal from the monitoring device with a control signal, and provide an output signal that is generally proportional with the deviance, if any, of the input signal from the control signal.

The positioning device can be electrically or pneumatically driven, depending on the input signal, space available for same, valve type, and so forth. The butterfly valve shown may be replaced by numerous other regulating valve types, or other devices adapted to regulate the flow (or conceivably temperature) of the cooling gas or air supplied to the cooling ring. The blower can supply refrigerated or ambient gas or air as would be found most optimum or necessary for any given blown film process and resins. The cooling ring is necessarily in an area where it can influence the temperature of the film in the monitored area, or the height of the frost line, as applies. Most preferably the air ring is positioned generally in the area shown by the drawing. Understandably, other cooling devices can be substituted for the cooling ring shown, or employed together therewith (i.e., of the various types known to the art, such as internally positioned cooling devices).

Certain of the known blown film processes include operating modes that may necessitate some modification hereof in order to apply these teachings to such a process. For example, a revolving die head, or a revolving take-up assembly, or the like (i.e., such as to continually revolve tube **18**), is oftentimes employed in the blown film process for certain resins and to produce certain end products. The process described above can and has been applied to a revolving blown film process, in a like control procedure as that described above, essentially without modification. However, under certain conditions, it may be desirable to read or monitor several control areas about a revolving tube, and/or to employ an integrator to average the temperature in the monitored area(s), and/or to regulate a cooling change only at specific intervals, such as after each complete revolution of the film, as may be found desirable or advantageous in any specific film line.

In addition to controlling the film properties or qualities explicitly mentioned above, the control temperature and/or control frost line position can also be determined to beneficially affect the more consistent attainment of film qualities such as relates to the properties of tear and impact strength, and film shrinkage characteristics. The control temperature or control frost line height, as applies, would thus be determined in regard to such properties, empirically or otherwise, to attain more consistent achievement thereof.

## EXAMPLE I

The invention as described is applied to a polyethylene "revolving tube type" blown film process having a 20 inch diameter die head. An "IRCON MODLINE", non-contacting optical pyrometer or radiation thermometer, "Instrument Series 3400," is used as the instrument to sense and monitor the temperature of the film. A control area is defined that is at least about 3 inches below the frost line, and most optimally is about 9 inches below the frost line and at least about 6 inches above the die head. A control temperature of about 240° F is established. An "IRCON" proportional controller is employed, Instrument Series 3400, that receives continually the electrical output of the optical pyrometer and converts the same proportionally into a pneumatic output that controls an air piston motor having an integral butterfly valve. The latter unit or assembly is available under the trade designation "Valteck Vector One Butterfly Valve." An approximately 1500 CFM capacity blower unit is employed, and is operated at full capacity, subject to regulation only by the controlled position of the butterfly valve. The following Table I summarizes the results comparatively between control and no control situations, wherein: "Maximum Rate" refers to the maximum achievable rate possible, but not practical for commercial runs; and "Maximum Good Production" is the maximum rate at which "good" film is produced based on the qualities of acceptable film flatness and uniformity of gauge profile. The latter figures are given in lbs/hour and also 1000 lbs/month. The monthly figure reflects "down time" and other interruptions in the process.

TABLE I

| Description | No Control | Control |
|---|---|---|
| Max. Rate-Lbs./Hr. | 675 | 675 |
| Max. Good Prod.-Lbs./Hr. | 550 | 650 |
| Max. Good Prod.-M Lbs./Mo. | 380 | 419 |

## EXAMPLE II

The control process hereof is also tested in a still higher volume, polyethylene blown process or production line, employing 30 inch diameter die, the process being also of the revolving tube type. The control process and the apparatus for accomplishing the same, is essentially the same as described supra. The control temperature and control area is near the same as with Example I. Significantly increased production capacity, as compared with the "no control situation", is also demonstrated in this test, with the results being tabulated below.

TABLE II

| Description | No Control | Control |
|---|---|---|
| Max. Rate-Lbs./Hr. | 1000 | 1000 |
| Max. Good Prod.-Lbs./Hr. | 800 | 950 |
| Max. Good Prod.-M Lbs./Mo. | 439 | 520 |

What is claimed is:

1. In a blown film process wherein film is produced through extruding a continuous molten tube of a film forming heat plastified synthetic resinous material, stretching or drawing the tube about a trapped air or gas bubble, and simultaneously cooling the tube, the steps comprising: monitoring the temperature of the film in a controlled area that is positioned between the frost line and extrusion die head, the control area being remote from and spaced sufficiently downwardly from the frost line so as to be less influenced by crystallization effects, cooling the film about its circumference between the control area and extrusion die head, setting a control temperature for the control area, comparing the monitored temperature with the control temperature, increasing or decreasing the rate of said cooling step responsive to the conditions of upward or downward drift, respectively, of the monitored temperature from the control temperature, whereby the process is characterized by an essentially constant temperature in the control area irrespective of cyclic variations in the operating parameters of the process.

2. The process of claim 1 wherein said cooling step comprises the step of varying the rate of gas flow in an air ring positioned between the control area and extrusion die head.

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